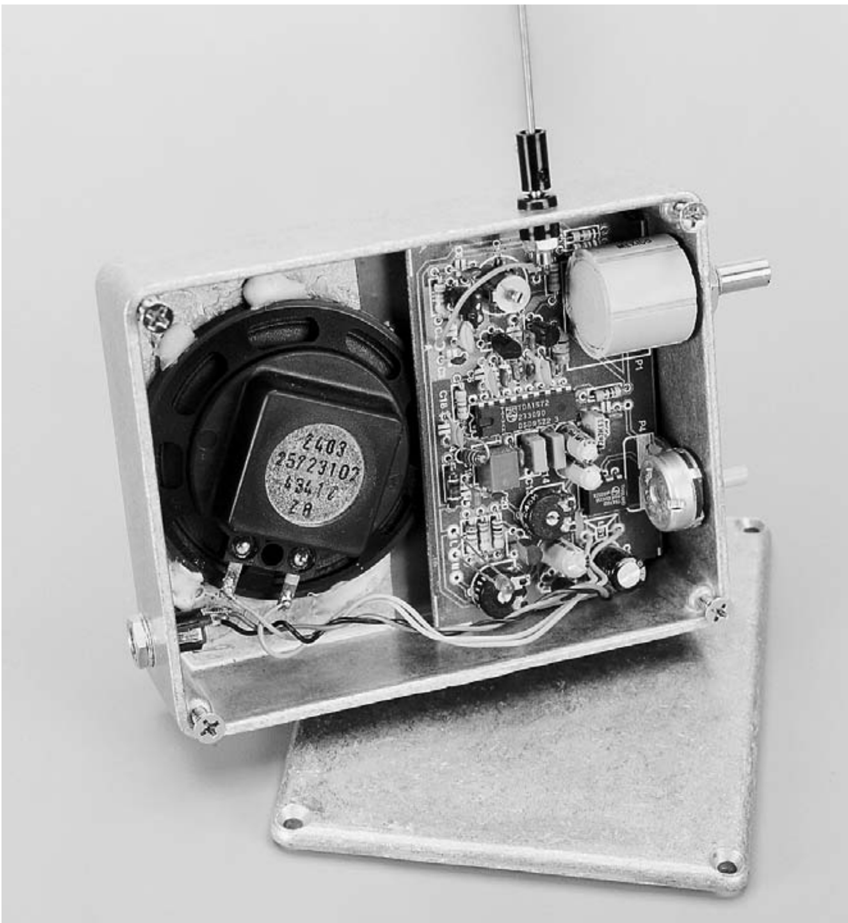
poor man's short-wave radio

small but effective

The design described in this article is one of those with immediate appeal. It is easy to build, very compact, and offers exceedingly good performance. Even with only a short whip antenna, it receives a myriad of broadcasting stations at good strength.



Some parameters

◆ *Frequency range*	*approx. 5.5-12.5 MHz (25 m, 31 m, 41 m, and 49 m bands)*
◆ *Sensitivity (6 dB signal-to-noise)*	*approx. 1 µV*
◆ *AGC range*	*86 dB*
◆ *Intermediate frequency*	*455 kHz*
◆ *Audio power output*	*1 watt into 8 Ω*
◆ *Quiescent current drain*	*about 50 mA*
◆ *Supply voltage*	*12–15 V*

Design by G Baars PE1GIC

Anyone with only the slightest interest in radio-frequency engineering will immediately be captivated by the tiny receiver described here. It is constructed on a printed-circuit board measuring 8.5×5 cm (3.4×2 in) and consists of only a handful of components, a whip antenna at the input and a small loudspeaker at the output. Nevertheless, it receives broadcasting stations from all over the world: the Voice of America; Radio Moscow; Radio Prague, not forgetting the BBC World Service when you're on holiday. And all that with a minimum of controls.

Four bands in one

The receiver is designed for operation over a single range containing the 25 m, 31 m, 41 m, and 49 m, short-wave bands. There is therefore no need for a band selector. It is tuned with the aid of

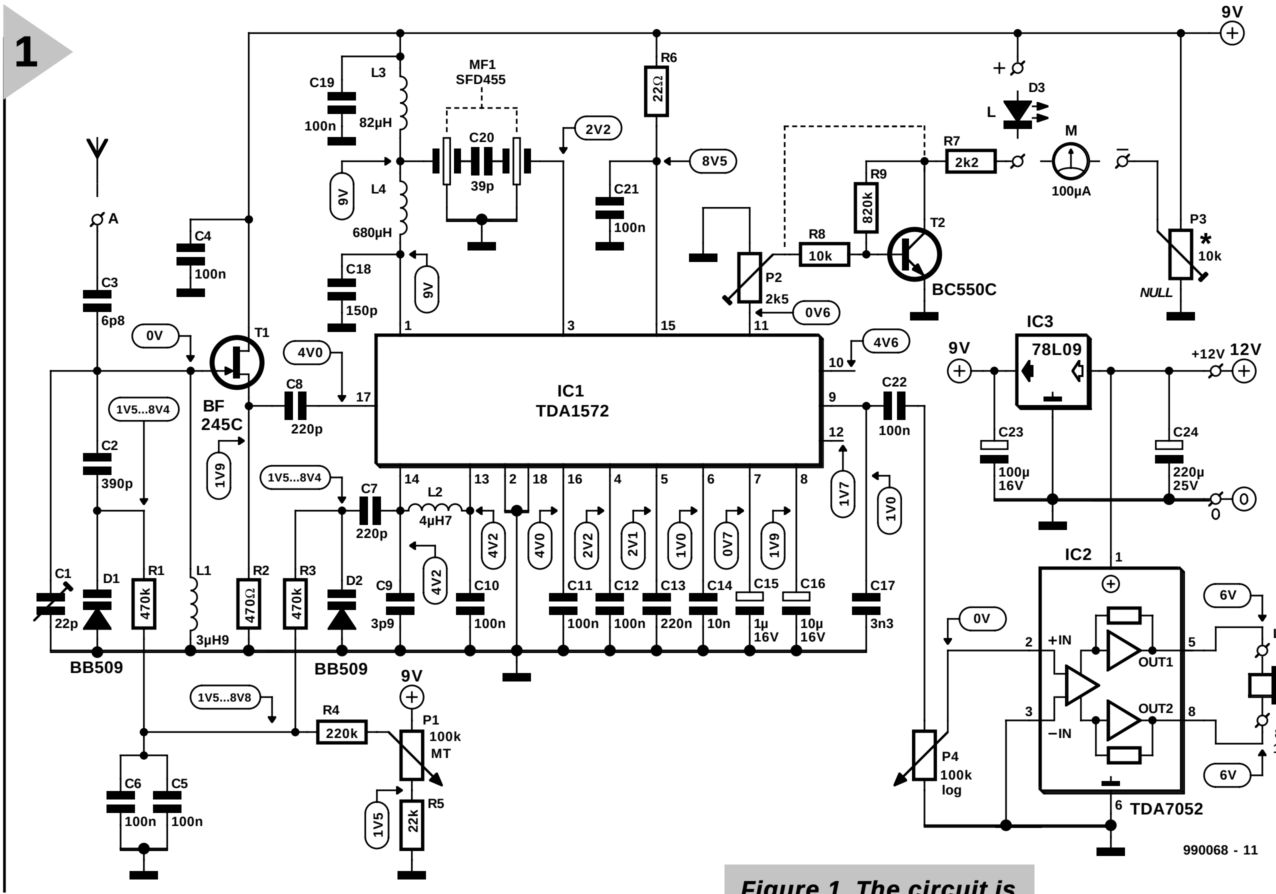


Figure 1. The circuit is based essentially on a Type TDA1572 integrated AM receiver.

varactors (also called voltage-controlled capacitors or voltage-variable capacitors – see inset) and a multi-turn potentiometer. The latter ensures that in spite of the very wide range, tuning is accurate and comfortable. The tuning indicator may be a light-emitting diode (LED) or moving-coil µA-meter.

The receiver is designed for the reception of amplitude-modulated (AM) signals only, since that is the universal mode of operation by broadcasting stations in the short-wave bands. The intermediate frequency (IF) bandwidth is 6 kHz, which ensures good audio reproduction.

TWO INTEGRATED CIRCUITS

The receiver is based on just two integrated circuits (ICs). One of these, IC2 in the circuit diagram in **Figure 1**, is a tiny audio-frequency (AF) amplifier that boosts the demodulated signal to an output power of about one watt. The other, IC1, a Philips Type TDA1572, is the circuit on which the radio-frequency (RF) operation is based. In fact, it is a complete integrated AM receiver, containing an RF amplifier, mixer, oscillator, IF amplifier, automatic gain control (AGC) and an AM demodulator.

Space in this article is insufficient to give a detailed description of the TDA1572, but much of this may be found on the Datasheet elsewhere in this issue. All that will be said here is that the mixer is a dual-balanced type and that in the design of the RF amplifier and demodulator great attention is paid to obtaining a large dynamic range and low distortion.

The oscillator is a voltage-controlled (VCO) type which is provided with temperature compensation. It works very well with a single inductor and is designed specially for use with varactors.

Finally, note that the TDA1572 has a dedicated output for a field-strength indicator.

The receiver is a single-conversion superheterodyne with an intermediate frequency (IF) of 455 kHz. From an operational point of view, this frequency should preferably have been somewhat higher to avoid the problem of image frequencies (see inset), but this is more than compensated by the simplicity of construction, the ready availability, and the low price of the 455 kHz filter used.

There are two tuned circuits: one for the input (L1-C2-D1-C2) and one for the oscillator (L2-D2-C7-C9). These circuits are tuned in synchrony with varactors D1 and D2, bearing in mind, of course, that the frequency of the local oscillator circuit is at all times 455 kHz higher than that of the input circuit.

The control voltage for the varactors is provided by a 9-V supply, regulated by IC3, via multi-turn potentiometer P1.

Note that inductors L1 and L2 are readily available small chokes.

The whip antenna is coupled to the hot end of the input circuit via capacitor C3. Although the input circuit could have been linked directly to the input pin (17) of IC1, this is not done deliberately, since the network connected to this pin inside the IC is low impedance, which would cause excessive damping of the input circuit. There is therefore a buffer in the shape of source follower T1 between the input circuit and pin 17 of IC1. The high input impedance of the buffer ensures a negligible load on the input circuit as well as on the (high-impedance) whip or telescopic antenna. This arrangement has a beneficial effect on the sensitivity as well as on the selectivity of the receiver.

The ceramic IF filter, MF1, is a balanced type, both resonators of which are interlinked by external capacitor C20. Inductors L3 and L4 match the impedance of the filter to that of the mixer. These inductors are also readily available small chokes.

The demodulated and pre-amplified audio-frequency signal is available at pin 8 of IC1, from where it is applied to integrated AF amplifier IC2 via volume control P4. Note that IC2 needs no external components whatever — its balanced output makes even an output capacitor unnecessary.

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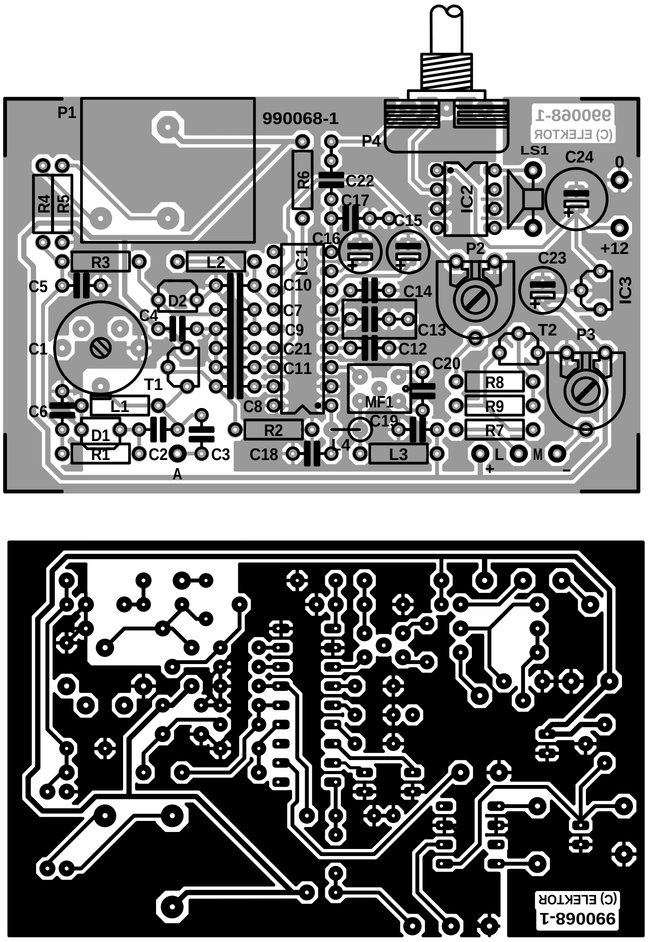


Figure 2. The PCB for the short-wave receiver including audio amplifier is notably small.

COMPONENTS LIST

Resistors:
R1,R3 = 470kΩ
R2 = 470Ω
R4 = 220kΩ
R5 = 22kΩ
R6 = 22Ω
R7 = 2.2kΩ
R8 = 10kΩ
R9 = 820kΩ
P1 = 100kΩ, 10-turn potentiometer
P2 = 2.5kΩ preset H
P3 = 10kΩ preset H
P4 = 100kΩ log. potentiometer

Capacitors:
C1 = 22pF or 40pF trimmer
C2 = 390pF
C4,C5,C6,C10,C11,C12,C19,C21, C22 = 100nF
C7,C8 = 220pF
C9 = 3.9pF
C13 = 220nF
C14 = 10nF
C15 = 1μF 16V radial
C16 = 10μF 16V radial
C17 = 3.3nF
C18 = 150pF
C20 = 39pF
C23 = 100μF 10V radial
C24 = 220μF 25V radial

Inductors:
L1 = 3.9μH
L2 = 4.7μH
L3 = 82μH
L4 = 680μH

Semiconductors:
D1,D2 = BB509
IC1 = TDA1572 (DIL18 case)
IC2 = TDA5072 (DIL8 case)
IC3 = 78L09
L = high-efficiency LED
T1 = BF245C or BF256C
T2 = BC550C or BC549C

Miscellaneous:
MF1 = SFD455 (Murata)
M = moving-coil meter, 50-200 μA
LS1 = 8 Ω, 1 W miniature loud-speaker
Enclosure: see text
PCB Order no. 990068 (see Readers Services section towards the end of this issue)

TUNING INDICATOR

As mentioned earlier, there are two possible tuning indicators. A moving-coil μA-meter (100 μA full-scale deflection — FSD) may be connected between the wipers of P2 and P3 via series resistor R7. Resistors R8 and R9 must then be replaced by wire bridges and T2 may be omitted. The FSD of the meter is set with P2 and its zero deflection with P3.

If space or another reason precludes the use of a μA-meter, a high-efficiency light-emitting diode (LED) may be used. This must be connected between resistor R7 and the 9-V supply line. Potentiometer P3 is then not needed, but T2, R8 and R9 are.

POWER SUPPLY

Voltage regulator IC_3 ensures an accurate, stable 9 V supply for IC1 and the varactors. Audio amplifier IC2 may be supplied directly from the unregulated voltage(12-15 V), which may be provided by batteries but, since this requires 8-10 cells, and the quiescent current is about 50 mA, it is highly advisable to use a suitable mains adaptor.

CONSTRUCTION

Building the receiver should not present even relatively inexperienced hobbyists any problems. If the receiver is constructed on the printed-circuit board (PCB) in **Figure 2**, it should be possible to build it in about an hour and a half. Pay good attention to the correct polarity of the electrolytic capacitors and ICs, and particularly to the colour code of chokes L1–L4. If only two of these chokes are placed wrongly, the receiver will definitely not work properly.

Potentiometers P1 and P4 may be mounted directly on the board.

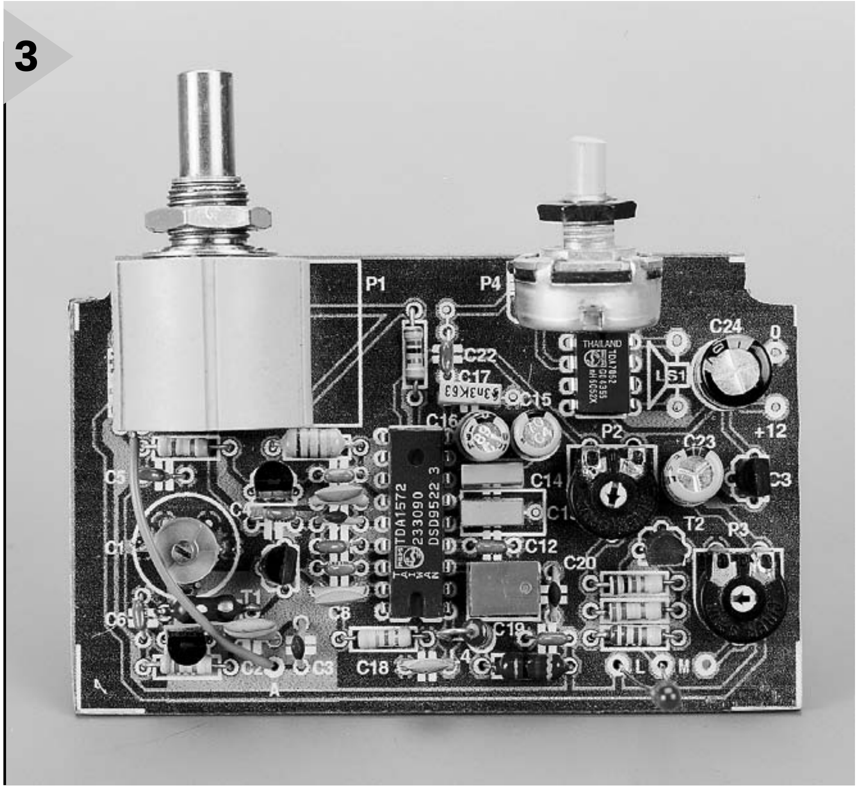
If an LED tuning indicator is used, solder its cathode (short terminal) to the solder pin marked 'L' and its anode to the + pin.

If a μA-meter is used as tuning indicator, connect it to the pins marked 'M' with its – terminal to the – pin.

When the board is completed (see the finished prototype in **Figure 3**), connect a whip antenna (or a 50 cm length of wire) to pin A, a small loudspeaker to pins LS1, and a mains adaptor to pins 0 and +12. At this stage, there should be some noise emanating from the loudspeaker, and when P1 is turned, there may even be some music or speech heard. If nothing is heard, carefully check the completed board. Also, the voltages at certain points should be compared with those indicated on the circuit diagram. Note that these voltages refer to a board without antenna and without reception of any station.

Once the receiver works correctly, it should be assembled in a suitable enclosure. The prototype is enclosed in a die-cast metal case from Hammond, but there are many other suitable cases. An ABS (plastic) enclosure may also be used, but this increases the risk of body effects and spurious radiation affecting the proper performance of the receiver.

Figure 3. Completed prototype receiver board.



SETTING UP

The setting up of the receiver is straightforward, since it contains only a single calibration element: trimmer capacitor C1. This is set to its optimum position as follows. Set potentiometer P1 to the centre of its travel, switch on the receiver and open volume control P4 slightly. Turn C1 until the noise emanating from the loudspeaker is a maximum. Then connect a whip antenna or a 50 cm — 20 in — length of wire to the input, turn P1 slowly anticlockwise (that is, from high to low frequencies) and tune to the first heard station that gives a reasonable strong signal. Readjust capacitor C1 for maximum audio output.

When an LED indicator is used, adjust P2 until the indicator just lights at the reception of weak stations and much more brightly with strong signals.

When a µA-meter tuning indicator is used, adjust P3 until the meter shows zero in the absence of a signal. Follow this by adjusting P2 for full-scale deflection when a strong station is being received. It is advisable to repeat these adjustments a couple of times.

[990068-1]

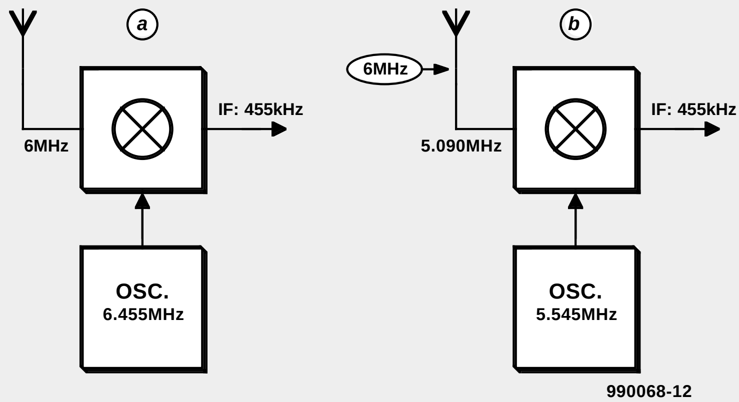
Varactors

A varactor or voltage-controlled capacitor is a two-terminal solid-state device that uses the voltage-variable capacitance of a p-n junction. In the design of a normal semiconductor diode, steps are taken to minimize inherent capacitance, whereas in a varactor this is emphasized. Since this capacitance varies with the applied voltage, varactors may be used as voltage-variable capacitors.

Image frequencies

In superheterodyne frequency converters or receivers, an image frequency is an undesired input frequency capable of producing the selected frequency by selecting one of the two sidebands produced by beating. The word 'image' implies the mirror-like symmetry of signal and image frequencies around the beating oscillator frequency or intermediate frequency, whichever is higher.

Consider, for instance, Figure A. Here, the receiver is tuned to a station at 6 MHz. Since the IF is 0.455 MHz, the oscillator is tuned to 6.000 + 0.455 = 6.455 MHz. In Figure B, the same receiver is tuned to a station at 5.090 MHz, so that the oscillator runs at 5.090 + 0.455 = 5.545 MHz.



Although the receiver in the second case is tuned to 5.090 MHz, the image frequency of the 6 MHz station is also received, since this station also produces an IF of 6.000–5.545 = 0.455 MHz.

Image frequencies are precluded by the use of a high IF, since this makes the difference between the original and image frequencies so large that the image is rejected by the input filter circuit. A further remedy consists of increasing the selectivity of the circuits preceding the mixer. In a simple receiver as the present, these remedies are not easily implemented: the most effective remedy against image frequencies here is the use of a short antenna.